COCCINELLA MAGNIFICA (REDTENBACHER): A MYRMECOPHILOUS LADYBIRD

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Coccinella magnifica Redtenbacher (the scarce 7 spot ladybird) (syn. *C. distincta* Faldermann, *C. divaricata* Oliver) is rarely recorded in Britain. This is because it is very similar in appearance to *Coccinella 7-punctata* (L.) (the 7 spot ladybird). Both species are of a similar size, and are red, usually with three spots on each elytron and a shared scutellary spot flanked anteriorly by two small white or off-white triangular markings. At first glance they are difficult to distinguish even if both species are held together for comparison. *Coccinella magnifica* has a more domed appearance (Fig. 1), the elytra dropping to the sides and back more sharply than those of *C. 7-punctata* (Fig. 2). The spot at the centre of the elytron of *C. magnifica* is usually larger and more obviously wider than long than that of *C. 7-punctata* (compare Figs 1 and 2). The front lateral spot of the *C. magnifica* is usually very small (Fig. 1). Both species may have one or occasionally more additional spots on each elytron, usually near the front outer angle, but additional spots are more common in *C. magnifica* (e.g. Fig. 3). The pale triangular marks flanking the scutellary spot tend to be less distinct and more dingy in *C. magnifica* than in *C. 7-punctata*. The front angle of the pronotum is more rounded in *C. magnifica* than in *C. 7-punctata* (see Figs 4 and 5). However, all these distinguishing characteristics are variable in both species making identification somewhat subjective and unsatisfactory. The only definitive deterministic feature which does not depend upon dissection is to be found on the underside of the thorax. *Coccinella magnifica* has the epimerae of the meso- and meta-thorax white, while *C. 7-punctata* has the epimerae on the meta-thorax white but those on the meso-thorax black (see Figs 6 and 7).

The scarcity with which *C. magnifica* is recorded may be gauged from the results of the Cambridge Ladybird Survey. Between October 1984 and December 1988, *C. magnifica* was the second least recorded of the 24 British ladybirds, the only species being found less often being the 13 spot ladybird (*Hippodamia 13-punctata*) which is probably extinct in Britain. Apart from those which the author has found himself, and a record of 'abundant in Hamsterley Forest (where there are stacks of *Formica rufa* nests)', records of only ten individuals from seven sites, have been sent to us since the instigation of the Cambridge Ladybird Survey, and this despite over three and a half million records of other species of ladybird from all over the British Isles. The distribution of *C. magnifica* is given in Fig. 8.

The paucity of records of *C. magnifica* can only partly be attributed to the difficulty in distinguishing it from *C. 7-punctata*. Undoubtedly it is rare, and its rarity appears to be a consequence of an unusual specialization. It is adapted to living close to the nests of ants, particularly those of the wood ant *Formica rufa* L. Of over 1400 *C. magnifica* found in the wild by the author since the summer of 1984, only one was not found in the sphere of influence of a nest of *F. rufa*. This was a single specimen netted in flight in a meadow in North Hampshire. The other records came from ten sites, three in Surrey and one each in Kent, Sussex, Hampshire, Dorset, Bedfordshire, Cambridgeshire and Suffolk. Studies of four colonies of *C. magnifica* and rearing the species in the laboratory, have shed some light on the general biology of the *C. magnifica* and the reasons for the association between this species and *F. rufa*.


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Fig. 8. The distribution of *Coccinella magnifica* in Britain. (From Cambridge Ladybird Survey records 1984–1988.)

Fig. 1. *Coccinella magnifica*, lateral view; note strongly domed appearance at posterior and transverse shape of central spot.
Fig. 2. *Coccinella 7-punctata*, lateral view; note generally shallower appearance, and less obviously transverse shape of central spot.
Fig. 3. *Coccinella magnifica*, lateral view; note additional spot close to front-angle of elytron.
Fig. 4. *Coccinella magnifica*, anterior view; note rather curved front-angle of pronotum.
Fig. 5. *Coccinella 7-punctata*, anterior view; note rather pointed front-angle of pronotum.
Fig. 6. *Coccinella magnifica*, ventral view; both meso- and meta-thoracic epimerae are white.
Fig. 7. *Coccinella 7-punctata*, ventral view; note meso- thoracic epimerae are white, meta-thoracic epimerae are black.

A colony on Chobham Common, close to a large nest of *F. rufa* has been situated on the same spot since before 1973. This colony has been visited on numerous occasions since the summer of 1984.

A colony in Bedfordshire, centred on a rather small *F. rufa* nest has been visited 13 times since it was discovered in 1985. The third study colony, was found in the New Forest, in 1986. The colony is the largest of the four in area, being perhaps a composite of two colonies centred on two nests of *F. rufa* which are situated about 80 metres apart. The only colony larger in area which I have seen is on Esher Common. Here *F. rufa* nests are situated at intervals all along the edge of a mixed coniferous and deciduous wood, and *C. magnifica* is to be found quite commonly along a stretch extending for almost half a mile.

These three study colonies are all situated on *Erica* and *Calluna* heathland with associated Scots pine (*Pinus sylvestris* L.) and some deciduous trees, particularly birch (*Betula* sp.) and oak (*Quercus* sp.). At two of the sites gorse bushes (*Ulex europaeus* L.) grow within 15 metres of the nests of *F. rufa* and these bushes appear to be favoured as overwintering refuges for *C. magnifica* at these sites.

The fourth study colony was discovered in East Dorset in July 1988. It is numerically the largest colony, over 300 individuals being counted on the afternoon that the colony was first discovered. This region of Dorset is characterized by areas of *Erica* and *Calluna* heathland on sandy soils. However, the colony was in a development area, situated along the verge between a residential estate and a busy dual carriageway. A nest of *F. rufa* was situated below a single mature Corsican pine (*Pinus nigra* L.). Most of the ladybirds when first discovered were feeding on black aphids on ragwort (*Senecio jacobaea* L.) with a few on evening primrose (*Oenothera biennis* L.). All the ladybirds were of a light orange–red colour characteristic of ladybirds that have recently emerged.

To test whether the association between *C. magnifica* and *F. rufa* is necessary for the successful reproduction of the ladybird, four attempts have been made to breed the species in the laboratory. In 1984, a single female ladybird from Surrey was brought to the laboratory. She was housed in a petri dish and fed on live pea aphids (*Acyrthosiphon pisum* Harris). Two days after her capture she laid a batch of eight eggs. A further nine batches of eggs, totalling 51 in all, were laid over the next 3 weeks. Most of the eggs hatched, the young larvae being fed on pea aphids. There was some early mortality and later some cannibalism among the larvae, but 15 larvae pupated successfully, and of these 12 hatched into apparently healthy and full-sized adults. The successful rearing of *C. magnifica* from oviposition to adult emergence in the complete absence of ants of any kind, suggests that the wood ants are not essential to the reproduction of *C. magnifica*. However, this contention would carry more weight if it could be shown that mating took place in the absence of the ants.

In 1985, two males and a female *C. magnifica* were sent to us from Scotland. One of the males mated with the female, she subsequently laid eggs and the larvae were reared to the adult state, again on pea aphids. While it is not possible to be sure that the mating observed was successful and responsible for the fertility of the eggs that were subsequently laid, the observation of mating suggests that close proximity to ants or an ants' nest is not necessary for mating.

This was confirmed in 1986 when seven *C. magnifica* larvae were found in Hampshire. These were reared and the resulting adults, which were obviously known to be virgin, mated and laid fertile eggs in the laboratory in the complete absence of ants. These were reared to the adult stage. The majority of the progeny were retained in the laboratory, at around 21°C, and were fed on pea aphids. Although these appeared to thrive and some survived for more than 7 months they

were not seen to mate and the very few eggs that were laid were infertile. A small sample of 17 of the progeny had been split off in October and placed in a perspex cage 46 × 46 × 46 cm. The floor of the cage was covered in peat, and bark, pine twigs, needles and cones, egg boxes, and corrugated cardboard were placed inside. The cage, was placed in an unheated insectary on October 17. During mild weather over the next six months, six 1-cm cubes of an artificial ladybird food (for details of this food see Majerus & Kearns, 1989) were placed in the cage on a petri dish lid. The food was replaced a week later if the mild weather persisted.

The cage was brought back into the laboratory on 11 April and the ladybirds were fed on pea aphids. Eleven *C. magnifica* had survived. These began feeding almost immediately, and within 48 hours three pairs were seen mating. Eggs were laid the following day and on many subsequent days. Nearly all the eggs were fertile and the first resulting adults emerged on 29 May. This result showed conclusively that contact with ants is not essential for reproduction in this species, for neither these second generation adults, nor their parents, were ever in contact with any ants. It also suggested that a period of dormancy is essential to reproduction. However, this latter conclusion has subsequently been put in doubt. A sample of 12 *C. magnifica* taken from the Dorset colony on the day it was discovered (6 July 1988) were taken back to Cambridge. All appeared from their ground colour which was pale orange, to be newly emerged adults, and quite different from the much deeper red of adults which have overwintered. These 12 were fed on pea aphids in the laboratory for several weeks, being kept at approximately 21°C the whole time. On 25th August a batch of eggs was laid. Although no mating was observed, these were fertile producing adults by the third week of September. Subsequently, matings were observed and further eggs were laid throughout September. In November the progeny began to mate and oviposit, producing a third generation in January 1989.

Coccinella magnifica is comparatively easy to rear in the laboratory, given a good supply of live aphids of a suitable species. The duration of the early stages is very similar to that of the *C. 7-punctata.* When kept at 21°C, ova hatch within 6 days, the larvae feed up in 3 to 4 weeks and the adults emerge from the pupae about 10 days later. If anything, larval cannibalism and larval mortality is less than in *C. 7-punctata* and matings seem more easy to obtain.

One suggested reason for the association between *C. magnifica* and *F. rufa* was that the ladybirds overwinter in the ants' nests. This was investigated by obtaining a series of population size estimates using mark–release–recapture techniques on the New Forest colony. During a series of visits between September 1987 and May 1988, all *C. magnifica* that could be found were collected for a radius of 50 metres around the two nests upon which this colony is centred. The majority of *C. magnifica* throughout this period, except in May 1988, were found on gorse bushes with small numbers on pines and heather. In May 1988 most of the ladybirds were on the

Table 1. Population size estimates for a *C. magnifica* colony in the New Forest 1987/88.

Date	Total previously marked	Number in sample	Number marked	Population estimate
September 1987	69	53	9	406
December 1987	113	47	14	379
January 1988	146	61	22	405
February 1988	185	50	29	319
March 1988	207	39	24	336
May 1988	223	58	41	315

heather. No ladybirds were found on or in the nests. All were marked with tippex and released, different mark positions being used each visit. Population size estimates were obtained for September 1987, December 1987, January 1988, February 1988, March 1988 and May 1988. The population size estimates are given in Table 1.

Comparison of these estimates shows that the number of ladybirds remained relatively consistent throughout the winter. There appears to have been a gradual decrease in population size throughout the period. This decrease is probably

Table 2. Numbers of coccinellids of different species found at specific distances away from nests of *F. rufa*, at three sites.

Distance from nest (metres):	0–10	10–20	20–30	30–40	40–50
Chobham Common					
Coccinella magnifica	26	22	4	1	0
Coccinella 7-punctata	1	1	11	28	26
Coccinella hieroglyphica	2	0	3	6	8
Chilocorus 2-pustulatus	0	0	1	4	3
Exochomus 4-pustulatus	0	0	0	2	4
Adalia 10-punctata	0	1	0	2	0
Propylea 14-punctata	1	0	2	2	1
Calvia 14-guttata	1	0	1	0	1
Anatis ocellata	0	0	0	1	3
Bedfordshire					
C. magnifica	31	42	17	3	0
C. 7-punctata	4	3	18	38	91
C. 2-pustulatus	0	0	0	4	5
Adalia 2-punctata	0	0	1	2	6
A. 10-punctata	1	0	1	2	0
P. 14-punctata	0	2	2	7	6
Myrrha 18-guttata	1	0	0	0	0
Harmonia 4-punctata	0	0	0	1	0
*New Forest (nest a)**					
C. magnifica	16	13	5	4	2
C. 7-punctata	2	3	10	17	20
C. hieroglyphica	0	0	0	1	1
E. 4-pustulatus	0	0	2	0	2
A. 10-punctata	0	1	0	0	1
C. 14-guttata	0	1	0	0	1
M. 18-guttata	0	0	3	0	1
*New Forest (nest b)**					
C. magnifica	27	31	12	7	4
C. 7-punctata	4	2	9	28	29
C. 2-pustulatus	1	0	1	0	1
E. 4-pustulatus	0	0	2	3	6
P. 14-punctata	1	0	0	2	0
M. 18-guttata	0	2	0	3	3
Mysia oblongoguttata	0	0	1	0	0
Totals (all sites)					
C. magnifica	100	108	38	15	6
C. 7-punctata	11	9	48	111	166
All other species	8	7	19	42	53

* The New Forest site was centred on two *F. rufa* nests, a and b, approximately 80 metres from one another. As a was situated north-west of b, none of the 50 metre transects encroached within 50 metres of the other nest.

attributable to natural mortality, a likelihood reinforced by a detailed analysis of the dates that recaptured individuals were marked. There was no substantial decrease between September and December 1987, nor any increase between March and May 1988, both of which would have been expected if a substantial portion of the population had overwintered in the *F. rufa* nests.

The question remains as to why the species in the wild appears to be so closely associated with the ant *F. rufa*. At one time I thought it possible that the association might be more apparent than real. The association between *C. magnifica* and *F. rufa* was first noted by Donisthorpe (1939) and was affirmed by Pontin (1960). In 1984 when I asked Dr John Muggleton for information on where and how to find the species, he mentioned the association, and told me of the location of the Chobham Common colony. It subsequently occurred to me in the winter of 1985/86 that I only really sought *C. magnifica* when I was aware of a nest of *F. rufa* in the area I was working. Otherwise I generally ignored *C. 7-punctata*, and did not scrutinize them carefully to confirm their identity. Consequently, during 1986, while collecting at a total of 26 sites in Dorset, Hampshire, Sussex, Surrey, Cambridgeshire and Suffolk, I checked the identity of 5971 seven spotted ladybirds. These were collected without consideration of the presence or absence of *F. rufa* nests in the vicinity. Apart from 38 ladybirds found at the New Forest site mentioned previously and 11 ladybirds found at the Chobham Common site, all were *C. 7-punctata*. So, despite an exhaustive search, mainly in counties where I knew *C. magnifica* could be found, none were found except in the proximity of *F. rufa* nests. The association is real, not apparent.

Two possible causes for the association between *C. magnifica* and *F. rufa* may result from the aggressive behaviour of the ants towards intruders in general, and to aphid predators in particular.

While recording *C. magnifica* I gained the impression that generally very few species of ladybird apart from *C. magnifica* were to be found within the main sphere of influence of an ants' nest.

Consequently, during 1985 the colonies at Chobham Common, and in Bedfordshire, and during 1986 the colony in the New Forest, were surveyed for all ladybirds. In each case, 1-metre wide transects, one running north/south, and a second running east/west, each centred on the ants' nest (at the New Forest site the colony was associated with two nests) and extending straight out 50 metres on either side of the nests, were carefully searched for any coccinellids. All were recorded with the distance away from the ants' nest being noted. The results are given in Table 2.

At all sites, within 20 metres of the nest, a substantial majority of all ladybirds found were *C. magnifica*. Thereafter, the proportion of *C. magnifica* declines rapidly as distance from the ants' nest increases. Conversely *C. 7-punctata* which is rarely found close to the ants' nest begins to increase from a distance of 20 metres from the nests. It seems possible that *C. magnifica* does not compete successfully with *C. 7-punctata* for food or for some other major requirement of life when the two species are present together. However, if *C. magnifica* is immune to ant attacks, while *C. 7-punctata* is not, then in the sphere of influence of a *F. rufa* nest, *C. magnifica* will not be in competition with its close relative.

The reaction of *F. rufa* to a variety of species of ladybird was studied during 1988. Ten adult ladybirds of each of eight species were placed on foliage between 5 and 10 metres from an ants' nest. The ladybirds were placed approximately 15 cm from a colony of aphids being tended by ants. In addition ten second instar and ten final instar larvae of both *C. 7-punctata* and *Adalia 2-punctata* (L.) were used in the same way. Finally, 30 adult, ten second instar, and ten final instar *C. magnifica* were placed

Table 3. Outcome of introducing coccinellids into close proximity of aphid colonies being tended by *F. rufa*.

Species	Not attacked by ants	Dropped off foliage	Carried away on foliage	Carried away on ground after dropping	Carried towards nest after dropping	Killed and left	Killed and carried towards nest	Ran away	Flew away
Coccinella 7-punctata	—	8	—	1	—	—	—	1	1
Adalia 2-punctata	—	7	1	2	—	—	—	—	2
Calvia 14-guttata	—	10	—	1	—	—	—	—	—
Propylea 14-punctata	2	3	—	—	—	1	—	2	5
Anatis ocellata	—	6	—	—	—	—	—	3	1
Myrrha 18-guttata	—	6	—	1	—	—	—	—	4
Exochomus 4-pustulatus	—	8	—	—	1	—	1	1	1
Aphidecta obliterata	1	—	—	—	—	—	7	—	3
Coccinella magnifica	30	—	—	—	—	—	—	1	1
Coccinella 7-punctata (final instar larvae)	4	10	—	3	—	—	—	—	—
Coccinella 7-punctata (second instar larvae)	—	4	—	—	—	4	1	1	—
Adalia 2-punctata (final instar larvae)	—	10	—	4	—	—	—	—	—
Adalia 2-punctata (second instar larvae)	—	3	—	—	—	7	—	—	—
Coccinella magnifica (final instar larvae)	10	—	—	—	—	—	—	—	—
Coccinella magnifica (second instar larvae)	10	—	—	—	—	—	—	—	—

in similar situations. The reaction of the ants to all these coccinellids was recorded, the results being summarized in Table 3.

In general, at least one ladybird–ant encounter occurred within a minute of a ladybird being introduced onto the foliage (except when the ladybird immediately took flight). On encountering a ladybird the ants initially tap it with their antennae and palps. For all species except *C. magnifica*, the ants then attacked the ladybird. The ladybirds' reaction was either to fly away, or to clamp down, withdrawing the legs under the body and 'reflex bleed'. Clamping down and reflex bleeding never caused the ants to break-off the attack, and usually more ants joined the attack. The ants attempt to gain a grip on the edge of the ladybird with their mandibles, or to push it up on one side to gain access to the underside where a grip would be easier to find. This pushing often resulted in the ladybird being toppled from, or knocked off, the vegetation. If a firm grip on the ladybird was gained by the ant, the ladybird was usually carried to the edge of the leaf and dropped off. Some of the ladybirds which were dropped off the vegetation took flight while they were falling. If they landed on vegetation close to ants they were often attacked again. A number of the ladybirds which fell to the ground were also attacked again, and if ants gained a grip on them, the ladybirds were usually carried or ant-handled away from the nest, some being carried up to 15 metres. Only very rarely were adult ladybirds killed or carried back to the ants' nest, except in the case of *Aphidecta obliterata* (L.). This is an exceptional coccinellid because it is cryptically, rather than warningly, coloured, and cannot reflex bleed (Brakefield, 1985). Seven out of ten of this species were killed and transported back to the ants' nest. The three which did not suffer this fate escaped by the simple expedient of taking flight.

Larger larvae of *C. 7-punctata* and *A. 2-punctata* were treated by the ants in much

the same way as the adults were treated. They were tapped, attacked, and because they are not able to clamp down, were generally picked up quickly and dumped off the vegetation. The larvae, when attacked, often attempted to escape by running or simply by falling from the vegetation themselves. The smaller larvae were usually killed by the ants, but were then generally left rather than being carried either back to or away from the nest.

The ants' treatment of both adult and larval *C. magnifica* was very different from that between ants and any other species of ladybird. After encountering *C. magnifica*, and touching it with antennae and palps, the ants would pass on, subsequently ignoring the ladybird (see also Pontin, 1960). In several instances ladybirds then found the aphid colonies and began feeding apparently with complete immunity from the ants attending the aphids.

But why do the ants not attack *C. magnifica*? One possibility is that the more rounded shape of *C. magnifica* affords some protection, making it difficult for ants to gain a grip on the ladybird. This seems unlikely to be the case because larvae of *C. magnifica*, which are also immune to ant attacks, would be afforded no such protection. A much more probable explanation is that *C. magnifica* secretes a pheromone of some kind which placates the ants. The nature of any protective secretion produced by *C. magnifica* is not known. It may be that, if there is one, it acts as a warning to advertise distastefulness or toxicity, although it is doubtful that this would deter the ants who appear to attack and remove other warningly coloured ladybirds primarily to protect aphid colonies which the ants attend to obtain honeydew. It is more probable that the secretion acts as a deceptive scent, either by mimicking the ants own scent, or by making the ladybird smell like an object that is apparently of no threat to the ants or aphids.

Whatever the reason for their immunity from ant attacks, it appears that areas close to the nests of *F. rufa* nests provide *C. magnifica* with a situation in which to live that is relatively free from other competing aphid predators.

Why then does *C. magnifica* not live away from *F. rufa* nests? It may be that they simply cannot compete successfully with other aphid predators. Yet during all my observations I have seen nothing to indicate that they are less able to find and secure food than other species of predatory ladybird. Nor have I gained the impression that they are less well adapted than other species. Although no resource necessary to the basic biological systems of *C. magnifica*, and provided by *F. rufa*, has been found, such may exist. Yet the ease with which the species can be bred and reared in captivity argues against this.

However, there may be benefits, other than avoidance of competition with other aphid predators, that may accrue from living near an aggressive predator, such as *F. rufa*. For example, predators and parasites of coccinellids may be kept away by the ants.

I have only once found the parasitic wasp *Perilitus coccinellae* (Schrank), which attacks a number of species of coccinellid, including *C. 7-punctata*, in *C. magnifica*, from a total of 119 individuals obtained and kept in conditions under which the presence of the parasite would have been determined. This compares with a parasitization rate of 4.38% in *C. 7-punctata* (from all appropriate observations, Majerus unpublished data). No other parasites have been recorded from *C. magnifica*.

One of the main groups of predators of ladybirds are spiders. A simple experiment on spider population density around nests of *F. rufa*, at two sites, was carried out in September 1988. Two 5 × 5 m areas of vegetation (mainly *Calluna* and *Erica* heathers) situated from 5 to 10 metres from *F. rufa* nests were surveyed using a sweep

Table 4. Relative abundance of spiders on heathland close to, or away from, *F. rufa* nests. (Sites a and b were between 5 and 10 metres from different *F. rufa* nests. Sites c–h were all between 100 and 150 metres from the nearest nest.)

Location/site	No. of spiders
New Forest a	29
Bedfordshire b	17
New Forest c	182
New Forest d	167
New Forest e	243
Bedfordshire f	171
Bedfordshire g	190
Bedfordshire h	140

net. The sweeping was carefully conducted, 50 sweeps being made on the 25 square metre plot. The process was repeated on six other similar plots (three at each site) each at least 100 metres from any *F. rufa* nest. The number of spiders on each plot is given in Table 4.

The number of spiders from the plots away from the ants' nests are between 5 and 11 times as great as the number from the appropriate plot close to a nest. The relative dearth of spiders near the nest may be a direct consequence of the aggressive behaviour of the ants, or could result from a low density level of potential prey for the spiders because of the ants. Either way, a low density of spiders; which are known to eat ladybirds that become entangled in their webs, would undoubtedly be beneficial to *C. magnifica*. A similar situation may exist in respect of other predators of *C. magnifica*.

It may be worth mentioning that at no time during my observations of *C. magnifica* and *F. rufa*, have I obtained any evidence that the ants gain a benefit from the presence of the ladybird.

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